ENVIRONMENTAL BARRIER MATERIAL FOR ORGANIC LIGHT EMITTING DEVICE AND METHOD OF MAKING

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a division of U.S. patent application Ser. No. 09/212,779, filed Dec. 16, 1998, now U.S. Pat. No. 6,268,695.

FIELD OF THE INVENTION

The present invention is related to environmental barrier material for organic light emitting devices (OLED), including light emitting polymer(s) (LEP). The environmental barrier prevents contact of environmental oxygen and/or water to the LED.

BACKGROUND OF THE INVENTION

Use of Light Emitting Organic Devices (sometimes known as Light Emitting Polymer, or LEP, Devices) in flat panel displays, and other information display formats, is currently limited by the poor environmental stability of the devices see C. Gustafson, Y. Cao, G. M. Treacy, F. Klavetter, N. Colaneri, and A. J. Heeger, Nature Vol. 35, Jun. 11, 1992, pages 477–479. Because of this poor environmental stability, devices are currently fabricated on glass substrates and have glass covers laminated over the top as an environmental barrier. Thus, even though the active portions of the device are of a lightweight, thin film, flexible polymer construction, the finished part is heavy and rigid because of the glass sheets needed as environmental barriers to protect the device from contact by permeation of oxygen and/or water vapor.

It has been previously reported that the single pass, roll-to-roll, vacuum deposition of a three layer combination on a PET substrate, namely

PET SUBSTRATE/PML Polymer Smoothing Layer/Oxide Layer/PML Layer can be more than three orders of magnitude less permeable to oxygen and water vapor than a simple oxide layer on PET alone. J. D. Affinito, M. E. Gross, C. A. Coronado, G. L. Graff, E. N. Greenwell, and P. M. Martin, *Polymer-Oxide Transparent Barrier Layers Produced Using the PML Process,* 39th Annual Technical Conference Proceedings of the Society of Vacuum Coaters, Vacuum Web Coating Session, 1996, pgs. 392–397, and J. D. Affinito, Stephan Eufinger, M. E. Gross, G. L. Graff, and P. M. Martin, *PML/Oxide/PML Barrier Layer Performance Differences Arising From Use of UV or Electron Beam Polymerization of the PML Layers,* Thin Solid Films, Vol. 308, 1997, pgs. 19–25. This is in spite of the fact that the effect on the permeation rate of the PML layers alone, without the oxide layer, is barely measurable. It is believed that the reason for this tremendous improvement in barrier properties was due to two mechanisms:

1) Permeation rates in the roll-to-roll coated oxide-only layers were found to be conductance limited by holes in the oxide layer that arose when the coated substrate was wound up over system idlers/rollers and onto itself in the take up roll. The oxide coating on the tops of the sharp features and debris, on the conformally oxide coated substrate, were found to fracture. These fractures were, apparently, because these rough surface features carried all of the load (since they stick up above the plane of the substrate) when the substrate is wound up after coating. In the single pass, PML/Oxide/PML process the PML smoothing layer covered all rough, sharp, and/or uneven features in the substrate topography as well as buried any foreign debris on the substrate surface. Thus, there were no high points to fracture.

2) The PML top coat also protected the oxide layer from damage due to rough portions of the system idlers/rollers as well as from the back side of the substrate as the material was wound up.

There is, therefore, a need to encapsulate LEP devices in a flexible, transparent, environmental barrier that permits viewing while preventing ingress of oxygen and water vapor from the environment.

BACKGROUND REFERENCES

1. G. Gustafson, Y. Cao, G. M. Treacy, F. Klavetter, N. Colaneri, and A. J. Heeger, Nature, Vol 35, Jun. 11, 1992, pages 477–479.
2. J. D. Affinito, M. E. Gross, C. A. Coronado, G. L. Graff, E. N. Greenwell, and P. M. Martin, *Polymer-Oxide Transparent Barrier Layers Produced Using The PML Process,* 39th Annual Technical Conference Proceedings of the Society of Vacuum Coaters, Vacuum Web Coating Session, 1996, pgs 392–397.
3. J. D. Affinito, Stephan Eufinger, M. E. Gross, G. L. Graff, and P. M. Martin, *PML/Oxide/PML Barrier Layer Performance Differences Arising From Use of UV or Electron Beam Polymerization of the PML Layers,* Thin Solid Films, Vol 308, 1997, pg. 19–25.

SUMMARY OF THE INVENTION

The present invention is an environmental barrier for an OLED. The environmental barrier has a foundation and a cover. Either the foundation, the cover or both may have a top of three layers of (a) a first polymer layer, (b) a ceramic layer, and (c) a second polymer layer. The foundation and/or the cover may have a at least one set of intermediate barrier each having (a) an intermediate polymer layer with (b) an intermediate ceramic layer thereon. In constructing the flexible environmental barrier, the foundation is made on a substrate. An OLED is constructed upon the top, opposite the substrate. The cover of at least a top then placed over the OLED to encapsulate the OLED. The placement or encapsulation may be by gluing or laminating the cover to the foundation over the OLED or preferably by vacuum deposition of the cover layers onto the OLED. It is most preferred that the substrate, foundation and cover be flexible.

For use as a display, it is preferred that either the ceramic layer(s) in the foundation, cover or both is substantially transparent to the light emitted by the OLED.

Each layer of the foundation and the cover is preferably vacuum deposited. Vacuum deposition includes monolayer spreading under vacuum, plasma deposition, flash evaporation, sputtering, chemical vapor deposition, evaporation and combinations thereof. It is further preferred that all layers are deposited and cured between rolls or rollers to avoid the defects that may be caused by abrasion over a roll or roller.

The subject matter of the present invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. However, both the organization and method of operation, together with further advantages and objects thereof, may best be understood by reference to the following description taken in connection with accompanying drawings wherein like reference characters refer to like elements.